way, only a compound of nickel is used in place of the compound of iron. The method by which these compounds are obtained and their constitution was not described in Dr. Kennelly's paper, but from the patent specification it appears that the compound of iron used is the monosulphide, FeS, which is formed after being made up into the briquettes by electrolytic oxidation in a solution of potassium hydroxide. The superoxide of nickel is prepared in the same manner by electrolytic oxidation of the ordinary hydrated oxide of the metal. Cobalt, it is said, can be used instead, but is more expensive. The briquettes of active material are placed in the little nickel-plated steel boxes, a cover is put on, and the boxes are then inserted in the "windows" of the grid. The assembled plate is then subjected in an hydraulic press to a pressure of about 100 tons (about 1 or 1½ tons per square inch), thus tightly closing the boxes and, by bending their sides over the edges of the recesses in the grid, fixing them firmly in position and making the whole into a rigid plate. The plates are separated, positive from negative, by thin perforated sheets of hard rubber, and are placed in a steel box which is filled up with the potash solution. The cell is then charged by passing current through it from the nickel to the iron plate, thus oxidising the nickel compound to superoxide of nickel and reducing the iron compound to spongy metallic iron.

It is obviously impossible to say at present how far this cell will satisfy the five conditions already stated. With regard to the first and the last, for example, no data are as yet available. The first is naturally one of the most important considerations, since it is necessary not merely that the cell should have a long life, but that it should not deteriorate too much even when subjected to somewhat careless treatment, as it is certain to be if it come into at all general use for motor-cars. Certain experiments which were quoted by Dr. Kennelly lead, however, to the hope that the cell will not be found wanting in this respect. Thus it was stated that the battery would stand without injury, not only being completely run down, but even being afterwards charged in the wrong direction. Mr. Edison also states that the nickel plate can be removed from the cell and dried in the air for a week without being injured, and if charged when thus removed will not appreciably lose its charge. The iron plate, if similarly treated, will lose its charge by the slow oxidation of the spongy iron, but will not be in any way permanently injured.

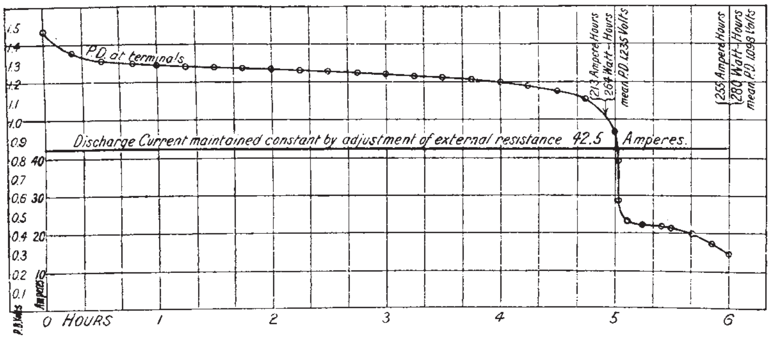

FIG. 2.—Curve of discharge of Edison cell weighing 25 pounds.

Perhaps the consideration that appeals most directly to motor-car users is lightness, or large storage capacity per unit weight. In this respect the cell compares very favourably with lead accumulators. According to Dr. Kennelly the storage capacity of the modern lead accumulator is from 4 to 6 watt-hours per lb., or from 9 to 13 watt-hours per kilogramme, whereas the Edison cell is said to have a capacity of 14 watt-hours per lb. (31 watt hours per kilogramme). It will be interesting to examine these figures a little more closely to see whether this claim to an increased storage capacity of about 3½ times is in reality justified. We reproduce in Fig. 2 a discharge curve for an Edison cell weighing 25lbs., discharging at 42·5 amperes for six hours. It will be seen that after five hours' discharge the voltage drops from 1·45 to 1·0 volt; although it may be possible to obtain the remaining hour's discharge without injury to the cell, yet it is very questionable whether this extra energy at so low a voltage as 0·5 volt would be found useful in practice. We are quite justified in saying, therefore, that this cell is only capable of giving five hours' discharge at 42·5 amperes, thus having a capacity of 213 ampere-hours, or 260 watt-hours. It has, therefore, a capacity of 10 watt-hours per lb. (22 per kilogramme), a figure somewhat lower than that given by Dr. Kennelly in the body of his paper. In an article on accumulators which appeared recently in the *Electro-Chemist and Metallurgist* (May 1901, p. 116), Mr. J. H. West gives a carefully calculated table of the capacities of all the principal accumulators exhibited at the Paris Exhibition or which took part in the Automobile Club competition of 1899. We can take from this table the figures relating to accumulators having a capacity of 200 ampere-hours and discharging in five hours, which are exactly comparable, therefore, with the Edison cell, the discharge curve of which is given in Fig. 2. Calculating from these data we get the results given in the accompanying table; there are 19 cells included in Mr. West's list, but as some of these are heavy cells intended for stationary work, a mean result has been worked out in which the heavier cells are neglected as well as a mean for the whole number.

TABLE.

Cell	Energy stored	
	Watt-hours per kilogramme	Watt-hours per pound
Mean of all cells in Mr. West's table	7	3
Mean of lighter cells ,, ,,	13	6
Lightest cell (Sherrin) ,, ,,	26	12
Edison's cell, from curve	22	10
,, ,, Dr. Kennelly's figures...	31	14

As the figures given by Mr. West only refer to ampere-hours, we have assumed in calculating the table that the mean voltage during discharge is 1·85 volts, a somewhat low estimate, and one therefore favouring the Edison cell in the above comparison. It will be seen from this table that the Edison cell when compared with the lightest lead accumulator obtainable is by no means so pre-eminent as regards energy capacity per unit weight. The Sherrin cell, it may be remarked, came very successfully through the Automobile Club's competition, being the only one which did not fall below the specified voltage more than three times during the trials. Although the figures given above may seem to militate against the claims advanced in favour of the new battery, it must be remembered that high storage capacity is not the only advantage that it is said to possess; even if it were no better than lead cells in this respect, if it proves superior to them in the other four conditions it will be a great advance. Also it must not be forgotten that the cell is quite new and that no doubt great improvement may be looked for when it is produced in large quantities.

THE BIOLOGY OF MOUNT SHASTA.

THE results of a biological survey of Mount Shasta, California, are contained in a *Bulletin*[1] recently received. This publication of 169 pages, with forty-six text illustrations and five heliotype plates, is a worthy successor to its forerunners, now so well known, and in every respect equal to the best of them.

It is the result of an investigation by the Biological Division of the U.S. Department of Agriculture under Dr. C. Hart Merriam, chief of the Biological Survey, which was decided upon in 1898, after the completion of the exploration of southern, middle, and north-east portions of the vast Californian area. The great altitude of the mountain (14,450 feet), and its position between the Sierra Nevada and the Cascades of

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[1] "North American Fauna," No. 16. U.S. Department of Agriculture. Washington: Government Printing Office, 1899.)

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Oregon, invest it with an exceptional interest, in relation to the question of the probable limitations in distribution of the animals and plants peculiar to these; and in the end the unexpected result has been obtained that, although the gap between the Shasta and the Cascades is far less than between it and the Sierra Range, and while plants and animals representative of both ranges are present upon it, the Sierra species are predominant.

In the course of the expedition names were given to newly-discovered peaks and canyons, and at points in the ascent favourable for work and observation individual members of the exploring party were left encamped, in one case for a period of well-nigh a couple of months. The net result biologically has been the discovery of five new species of plants, eight of mammals.

The Report opens with a description of the general features of the mountain; and its glaciers, basins, canyons, streams, slopes, timber-lines, and other natural features, are in turn dealt with in an amply and beautifully illustrated manner.

There then follows a systematic report upon the forest trees and a description of the life zones above 5500 feet, that being the altitude of limitation of the "transition zone" of the mountain, the facies of which are those of the surrounding country. The fauna and flora of this are given, and the superposed heights are next dealt with under zones as follows: the Canadian zone, of 2000 feet, which is defined as a "continuous forest of stately trees"; the Hudsonian, also of 2000, the highest of the timber-belts, characterised by the presence of but two species of trees—a hemlock and a white-bark pine; and the Alpine zone, or that occupying the interval between the timber-line and upper limit of plant growth.

The fauna and flora of each of these are in turn given in full in the form of classified lists of species. Then follows a discussion, with comparison, of the boreal flora and fauna of Shasta and the Sierra and Cascades, again with classificatory lists, and of the surrounding gaps and rivers, regarded as barriers to boreal species. The greater part of the Report which remains consists of a systematic list of the mammals and birds of the area, arranged in order of classification, with full diagnoses and measurements, and "remarks" which embody interesting observations on the habits of more especially the burrowing animals. There follows a chapter on the distribution of the Shasta plants. Concerning the zoological synonymy, many who are familiar with Dr. Merriam's work will be prepared for subspecies and what we in Europe are apt to regard as splitting. In this Report there is little of it, and when the richness of the materials which Dr. Merriam and his contemporaries usually command is borne in mind, criticism of this order were best left in abeyance. In the course of the strictly zoological portion of the Report several new text illustrations are introduced, and any more life-like and fascinating than those of the Rock Cony (*Ochotona* [*Lagomys*]), the Mink (*Lutreola*) and Marten, or among the birds, of the Red Tail and the Clark Crow it would be difficult to imagine.

Shasta is characterised by nothing better than its scanty moisture, and the effect of this on the plant population and zonal distribution is fully discussed. We have nought but the highest praise for this Report. It fills us with envy and arouses feelings of mute admiration for the enterprise of Dr. Merriam and his co-workers in the field. It is worthy the nation that will levy a tax to aid in the foundation and maintenance of a university, and where wealth, long lavished on scientific exploration of the land of their birth, is now bringing its reward of commercial prosperity.

THE NADIR OF TEMPERATURE AND ALLIED PROBLEMS.[1]

DETAILS are given in this paper which have led to the following results:—

The helium thermometer which records 20°·5 absolute as the boiling point of hydrogen, gives as the melting point 16° absolute. This value does not differ greatly from the value previously deduced from the use of hydrogen gas thermometers, viz., 16°·7. The lowest temperature recorded by gas thermometry is 14°·5, but with more complete isolation and a lower pressure of exhaustion, it will be possible to reach about 13° absolute, which is the lowest temperature that can be commanded by the use of solid hydrogen. Until the experiments are repeated with a helium gas thermometer filled at different pressures, with the gas previously purified by cooling to the lowest temperature that can be reached by the use of solid hydrogen, no more accurate values can be deduced.

The latent heat of liquid hydrogen about the boiling point as deduced from the vapour pressures and helium-thermometer temperatures is about 200 units, and the latent heat of solid hydrogen is about 16 units.

The order of the specific heat of liquid hydrogen has been determined by observing the percentage of liquid that has to be quickly evaporated under exhaustion in order to reduce the temperature to the melting point of hydrogen, the vacuum vessel in which the experiment is made being immersed in liquid air. It was found that in the case of hydrogen the amount that had to be evaporated was 15 per cent. This value, along with the latent heat of evaporation, gives an average specific heat of the liquid between freezing and boiling point of about 6 When liquid nitrogen was similarly treated for comparison, the resulting specific heat of the liquid came out 0·43 or about 6 per atom. Hydrogen therefore follows the law of Dulong and Petit, and has the greatest specific heat of any known substance.

The same fine tube used in water, liquid air, and liquid hydrogen gave respectively the capillary ascents of 15·5, 2 and 5·5 divisions. The relative surface tension of water, liquid air and liquid hydrogen are therefore in the proportion of 15·5, 2, 0·4. In other words, the surface tension of hydrogen at its boiling point is about one-fifth that of liquid air under similar conditions. It does not exceed one thirty-fifth part the surface tension of water at the ordinary temperature.

The refractive index of liquid hydrogen determined by measuring the relative difference of focus for a parallel beam of light sent through a spherical vacuum vessel filled in succession with water, liquid oxygen and liquid hydrogen, gave the value 1·12. The theoretical value of the liquid refractive index is 1·11 at the boiling point of the liquid. This result is sufficient to show that hydrogen, like oxygen and nitrogen in the liquid condition, has a refractivity in accordance with theory.

Free hydrogen, helium and neon have been separated from air by two methods. The one depends on the use of liquid hydrogen to boil the dissolved gases out of air kept at a temperature near the melting point of nitrogen; the other on a simple arrangement for keeping the more volatile gases from getting into solution after separation by partial exhaustion. By the latter mode of working something like 1/34000th of the volume of the air liquefied appears as uncondensed gas. The latter method is only a qualitative one for the recognition and separation of a part of the hydrogen in air. In a former paper on the "Liquefaction of Air and the Detection of Impurities" (*Chem. Soc. Proc.*, 1897), it was shown that 100 c.c. of liquid air could dissolve 20 c.c. of hydrogen at the same temperature. The crude gas separated from air by the second method gave on analysis—hydrogen 32·5 per cent., nitrogen 8 per cent., helium, neon, &c., 60 per cent. After removing the hydrogen and nitrogen the neon can be solidified by cooling in liquid hydrogen and the more volatile portions separated.

There exists in air a gaseous material that may be separated without the liquefaction of the air. For this purpose air has to be sucked through a spiral tube filled with glass wool immersed in liquid air. After a considerable quantity of air has been passed, the spiral is exhausted at the low temperature of the liquid air bath. The spiral tube is now removed and allowed to heat up to the ordinary temperature, and the condensed gas taken out by the pump. After purification by spectroscopic fractionation, the gas filled into vacuum tubes gives the chief lines of xenon. The spectroscopic examination of the material will be dealt with in a separate paper by Prof. Liveing and myself. A similar experiment made with liquid air kept under exhaustion, the air current allowed to circulate being under a pressure less than the saturation pressure of the liquid to prevent liquefaction, resulted in crypton being deposited along with the xenon.

A study of fifteen electric resistance thermometers as far as the boiling point of hydrogen has been made, and the results

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[1] (1) Physical Properties of Liquid and Solid Hydrogen. (2) Separation of Free Hydrogen and other Gases from Air. (3) Electric Resistance Thermometry at the Boiling Point of Hydrogen. (4) Experiments on the Liquefaction of Helium at the Melting Point of Hydrogen. (5) Pyro-electricity, Phosphorescence, &c. The Bakerian Lecture delivered at the Royal Society on June 13, by Prof. James Dewar, F.R.S.

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